Mapping and Interpreting the Armory Tailrace at Harpers Ferry National Historical Park

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Harpers Ferry National Historical Park (NHP) is home to a wealth of cultural resources spanning thousands of years from pre-contact Native American populations to the time of John Brown's infamous raid and the Civil War up to the town's inception as a Historical Park in the 20th Century. With this much accumulated history, the Park has a major responsibility to preserve, protect, and interpret the stories in a meaningful way. A large part of that responsibility falls upon the Division of Resource Management and its integral Archeology Program. This division is tasked with, among other things, documentation, investigation, and compliance with the laws governing these multi-faceted resources so that the public today and tomorrow can benefit from that shared heritage. Since a large part of the history of Harpers Ferry lies buried, archeology is intrinsically critical to the job at hand. Members of this program are therefore actively engaged in excavating cultural remains to help better inform the public.

In 2012 the Archeology Program completed another project focused on an intensive investigation of the Lower Armory Grounds. This land, acquired in 2001 from CSX Corporation, contains the remains of the second National Armory commissioned by the United States in 1798. An important part of this land acquisition was gaining access to remnants of the infrastructure that was integral to the operation of the Armory. One such feature is a tailrace tunnel. The investigation of the Armory Grounds and its only accessible tailrace highlights the Park's devotion to fulfilling its obligation of both understanding its resources in order to better protect them and presenting that information to the public for a more comprehensive experience of this facet of American History.

The entrance to the tailrace tunnel as it appears today. Historically, this would have been the exit point for the water that had passed through the waterwheel. Sedimentation from reoccurring floods and gradual erosion have reduced the size of the opening to only 3 ft. in height.

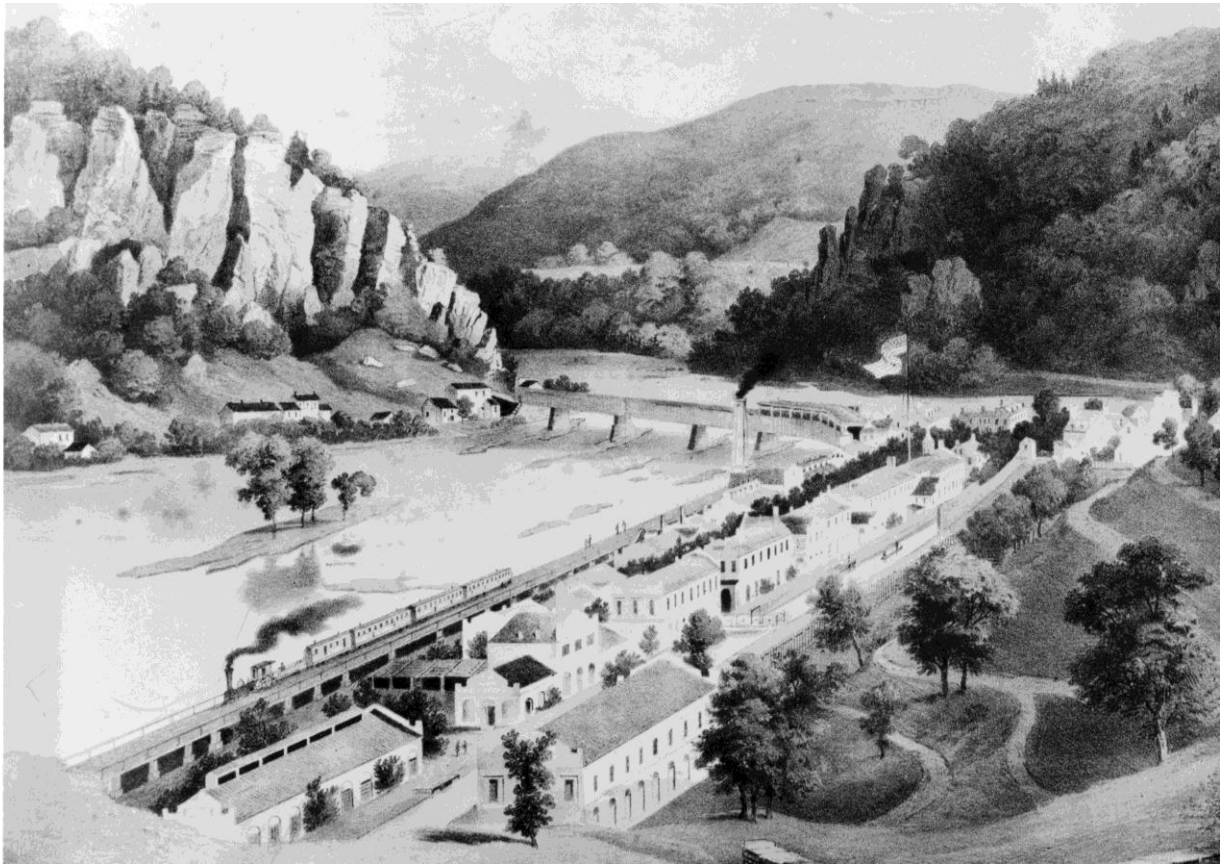
History of Harpers Ferry

Harpers Ferry began in 1733 as little more than a river crossing when Peter Stephens settled here and offered a needed service in manning a ferry. His control of the point of land at the confluence of the Potomac and Shenandoah Rivers ended in 1747 when Robert Harper purchased it from him. Harper formally acquired the land via an official grant in 1751. He saw the potential for both a continued ferry system and mills powered by the abundant water to process grains and saw wood. The economy of Harpers Ferry continued in this vein until the 1790s when the fledgling United States government, through the urging of George Washington, purchased land for a second national armory, the first being in Springfield, Massachusetts. Two land grants in 1796 and 1797 secured a total of 428 acres.

Construction began in 1799 with the establishment of a dam on the Potomac River and an adjacent canal along the south bank to provide water to the Armory. This was followed by multiple shops to manufacture weapons. Typical of the time, the manufacturing equipment within the shops was powered by water from the canal delivered through channels, known as raceways, that originally ran adjacent to the buildings and discharged into the Potomac River. Actual musket production finally got underway in 1801. As demand increased, the Armory expanded, going through several phases of major construction and refurbishment. During this time, the canal with its associated tailraces remained largely unchanged.

The Armory's close proximity to the U.S. capital, its position at the confluence of two great rivers, and the restricted passage through the Blue Ridge Mountain proved to be both a boon and a problem. Since the government had already invested so much in the Armory, it was only logical to continue improving the location. Subsequently, the main musket factory was followed by Hall's Rifle Works along the Shenandoah River, adjacent to the town. Harpers Ferry thus became an industrial center in its own right. The town and its industry were soon bolstered by two major transportation systems as well, the Chesapeake and Ohio Canal Company and the Baltimore and Ohio Railroad (B&O). By following the Potomac River, the canal and tracks invariably passed by the Armory and provided ready transport and supply lines.

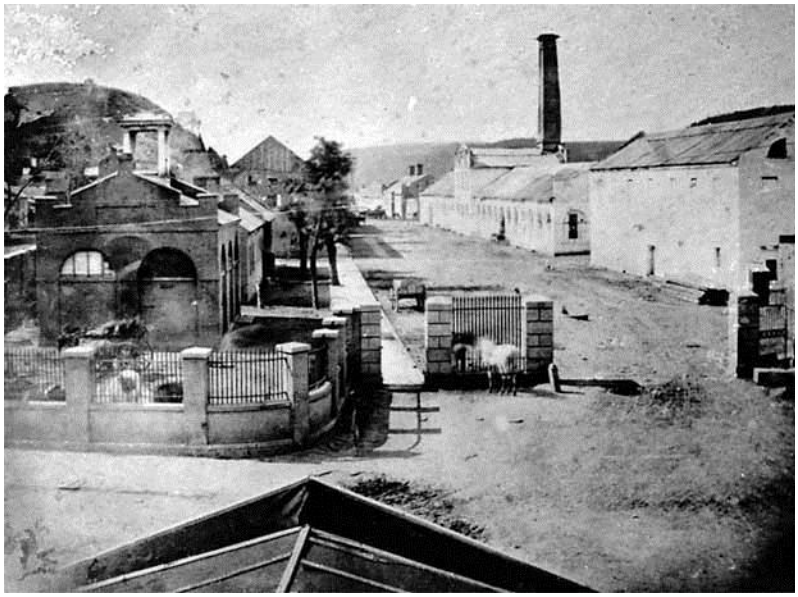
As a central hub and major weapons manufactory, the town also drew unexpected and dangerous attention. In 1859, John Brown sought to end slavery in the United States by raiding the Armory and using its store of finished weapons to arm slaves in a revolt. Two years later, in 1861, with the secession of Virginia from the Union, the state's soldiers marched into Harpers Ferry and seized the town in one of the strategic early moves of the



An artist's rendering of the Armory looking east towards the gap circa 1857. (Edward Beyer's Album of Virginia, HF 256.)

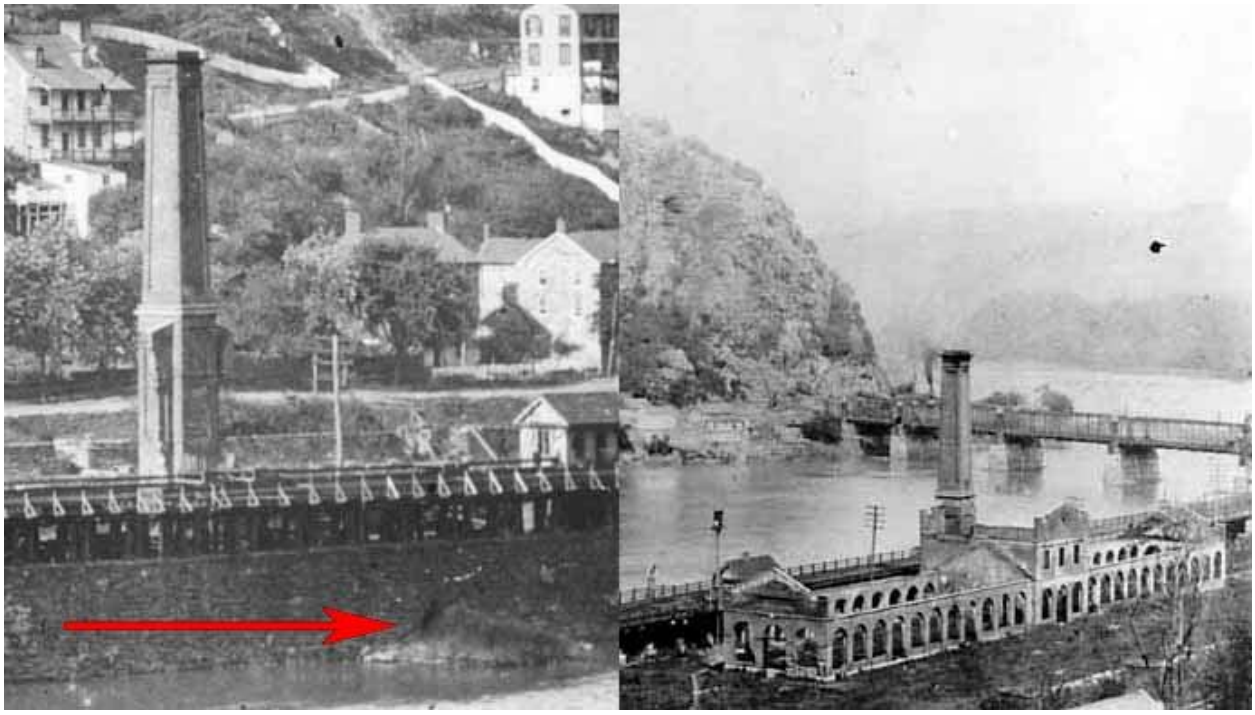
Civil War. Seeing the futility of defense, the small contingent of federal soldiers tasked with guarding the facility opted instead to deny the rebels by destroying the plant. They set fire to key buildings on the night of April 18, but were largely unsuccessful. Though the fires did substantial damage to multiple structures, their actions did not prevent the Confederacy from obtaining all of the necessary equipment to begin their own small arms manufactories in places like Richmond, Virginia and Fayetteville, North Carolina.

During the course of the Civil War, the town of Harpers Ferry changed hands multiple times. With each shift the fate of the Armory changed, as well. Buildings were demolished for various reasons and structural materials were reused elsewhere. The Union Army, however, also decided to renovate several of the shops for the purpose of a Quartermaster supply depot. They further utilized the Armory grounds for camps.



The Armory as it appeared in 1862 a year after musket production ceased as a result of the start of the Civil War. This is a view west from the main entrance looking down the central street of the facility. On the left is the Engine House made famous as John Brown's Fort. On the right, nearest the entrance, is the 1841 Warehouse followed by the Smith & Forging Shop with its 90 ft. tall smoke stack. (NPS Collection HF 0027)

With the war's end, the Armory fell, once more, into disuse. It was soon placed for sale by the United States government. Despite the potential for renewed industry using the remaining buildings and the still functional canal with its raceways, the property was not sold for nearly two decades. Then, in 1884, Thomas Savery purchased the entire grounds and existing structures to start a pulp mill business. Under his ownership only one of the remaining Armory



LEFT: The arrow points to the exit point of the tailrace tunnel within the river wall bordering the Potomac in this photograph of the remains of the Smith & Forging Shop smoke stack circa 1890 (NPS Collection HF 1155). RIGHT: A view of the remains of the Smith & Forging Shop looking east as taken on May 29, 1886 (NPS Collection HF 0752).

buildings was necessary for his business. The rest were gradually demolished until all that remained in 1891 was the Engine House, that became known as John Brown's Fort after he used it as a refuge in his failed raid, and the 90 ft. tall smoke stack of the Smith & Forging Shop. The Engine House was saved and taken to Chicago, Illinois for the World's Columbian Exposition, while the smoke stack was eventually leveled in 1892. With the removal of the stack, the last, most visible vestige of the original Armory was erased from the landscape.

After Savery, ownership of the Armory grounds ultimately passed to the B&O Railroad. The railroad made further changes to the physical appearance of the grounds. For example, between 1892 and 1894 the B&O Railroad established a new track alignment resulting in the creation of a 15 ft. high berm that covered the canal and many of the foundations of the shops on the southern side. With each alteration, the evidence of the original Armory faded further and further into memory. By the late 20th century vegetation had reclaimed much of the neglected land. Though interest in the Armory continued, it focused largely on the written and photographic historical record.

Excavation of the U.S. Armory grounds at Harpers Ferry NHP in 2007. (Photo by Robert E. Brzostowski.)

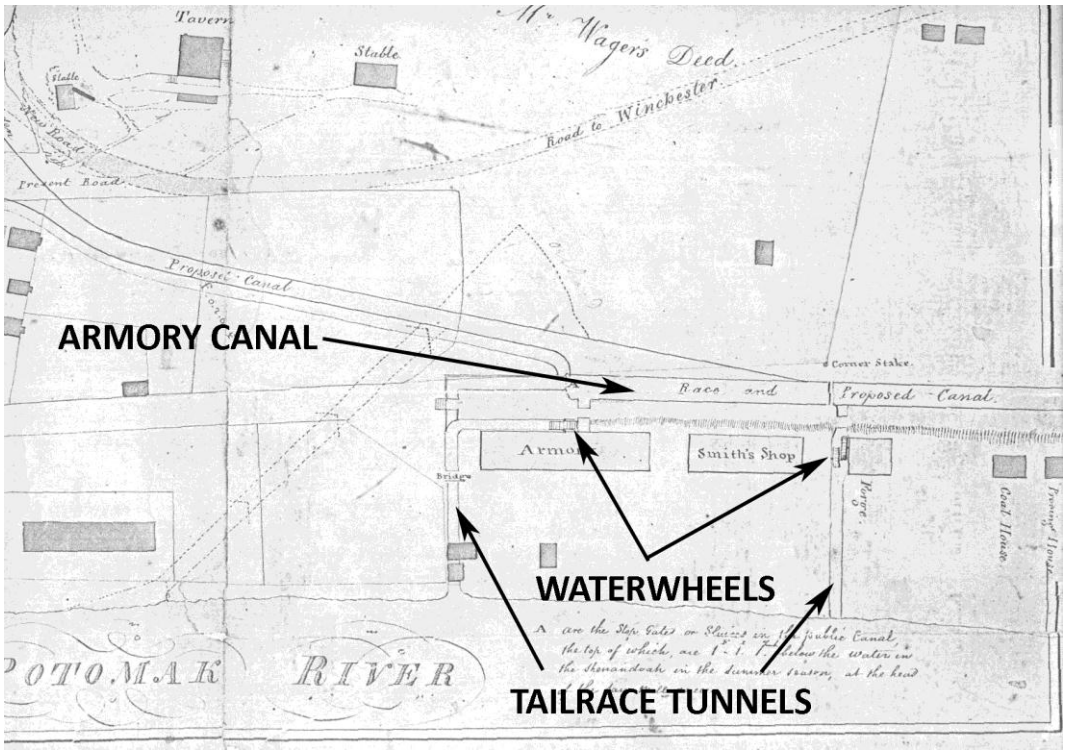
This was soon to change. In 2005 the Archeology Program at Harpers Ferry NHP brought new attention to the Armory through a series of excavations at the Smith and Forging Shop and the 1841 Warehouse. This was followed most recently by an investigation into the Armory Street and an exploration of the tailrace beneath it.

Waterpower and the Tailrace

Water power drove the Industrial Revolution, being cost effective, relatively efficient, and expedient. The kinetic energy of flowing water was being harnessed wherever possible to rotate waterwheels and, eventually, turbines. These devices converted that momentum into mechanical energy, which subsequently operated machinery. To achieve this mechanization at

Harpers Ferry in the late 1700s, one of the leading engineers in America, James Brindley, was contracted to design a canal. When completed, the canal measured 1.5 miles long by 15 ft. to 30 ft. wide. It functioned as the *headrace*, directing water from the Potomac River towards the awaiting waterwheels. Once the water passed through the wheel and its associated pit, it exited via another smaller channel known as a *tailrace*.

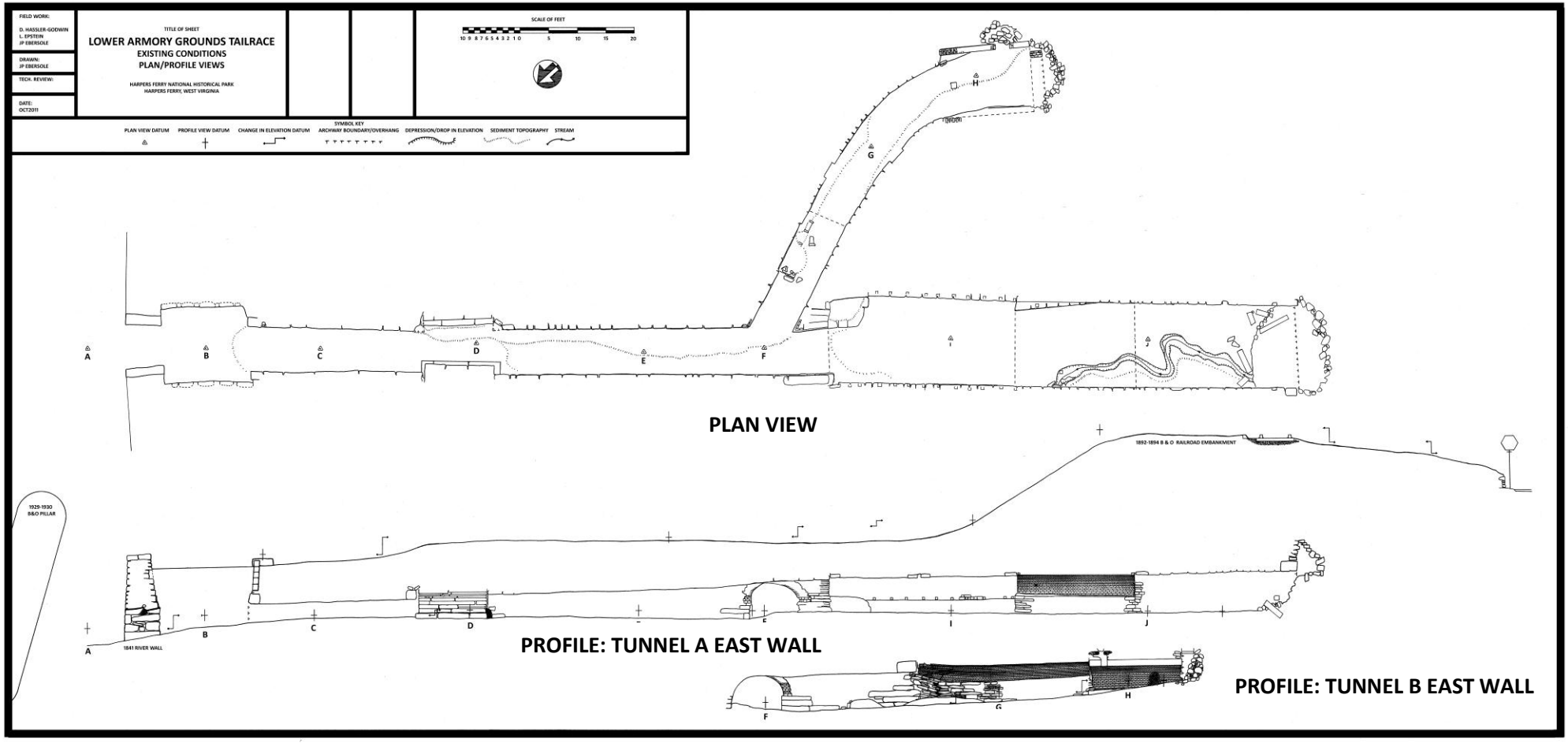
Information is scant, but the earliest Armory of 1801 definitely had two such open tailraces. Within these raceways sat anywhere from three to eight waterwheels providing power for two of the three main shops. By 1860, the manufactory had grown such that there were seven tailraces facilitating the operation of machinery and an eighth channel for excess water flow. The raceways were also vaulted by this time, allowing for a formal street, which acted as the main thoroughfare of the facility, to pass above them.



A plan view of the earliest organization of the Armory with its three main workshops labeled as *Armory, Smith's Shop,* and *Forge*. The Armory canal is shown with a proposed extension that would have connected it with a canal along the Shenandoah. This map was produced by King and Harbaugh in 1803 (National Archives).

Exploring the 19th Century Tailrace

Although critically necessary to any facility relying on waterpower to run machinery, tailraces are rarely seen as noteworthy features requiring intense



After four days of mapping, the crew of three produced this plan (TOP) and profile (BOTTOM) view of the Lower Armory Grounds Tailrace Tunnel. It reveals the interrelationship amongst the attributes of the tunnel and above ground features. The profile view on the bottom starts with the river wall on the left, followed by the open air culvert, then the east wall of tunnel A, and terminates beneath the railroad berm with its now unused tracks. Just beneath the profile of Tunnel A is a second profile focusing on the east wall of Tunnel B starting at the Y junction. The plan view on top is aligned to correlate with the profiles below. (Image by J.P. Ebersole, NPS.)

study. However, as past technologies become forgotten arts, these architectural vestiges contain substantial information to document those skills and periods of history. It is with these thoughts in mind that Harpers Ferry NHP Archeology Program staff documented a tailrace located within the park.

The tailrace within the Harpers Ferry Armory grounds may be unique in being one of the best preserved examples of a 19th century industrial raceway tunnel within federal possession. Its uniqueness was also the cause for concern. Under OSHA regulation 29 CFR 1910, the tunnel is defined as a confined space, requiring a permit, such as MSA Bulletin 5555-58, and certain safety precautions prior to entry. With the help of V. E. Sankbeil, Department of Veteran's Affairs, the Friendship Fire Company of Harpers Ferry, and NPS personnel, park archeologists met the requirements for authorized entry. They spent four days in October 2011 mapping and photographing the tunnel. By the end of the project, the team had successfully documented the tailrace despite mud, water, and confined spaces.

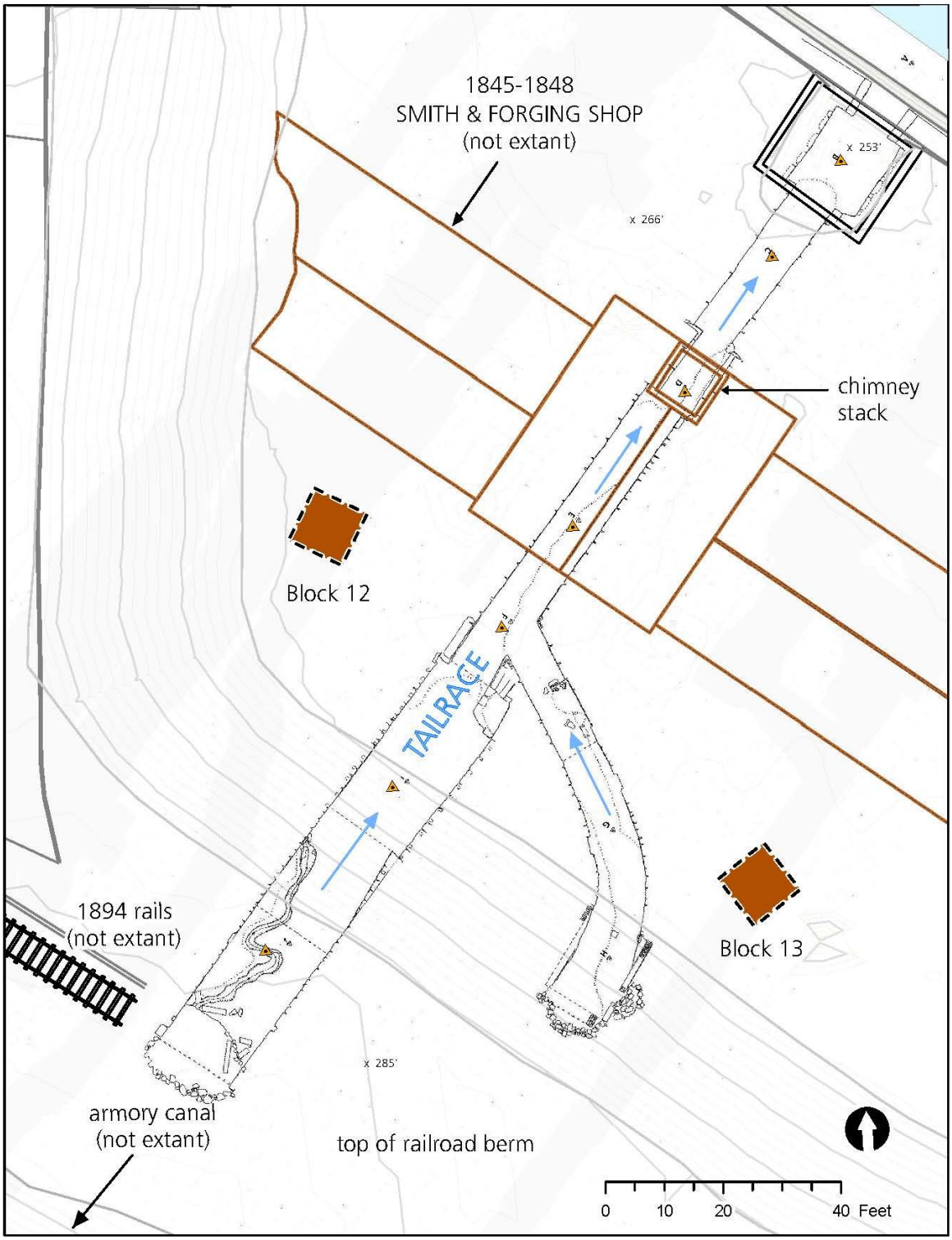
Exploration of the tunnel revealed a number of fascinating construction features. NPS archeologists found that the tunnel is not simply a single shaft but is, in fact, comprised of two sections forming something of a "Y" shape. The main shaft (Tunnel A) extends 183 ft. from its river side opening to a point where the B&O Railroad crew intentionally collapsed it as part of their 1892-94 berm construction. As for the secondary shaft (Tunnel B), it runs an additional 70 ft. from its intersection with the main tunnel at 86 ft. until it, too, ends at a deliberate collapse. Unlike the main shaft, though, this secondary tunnel has a curved portion facilitating its junction with the larger tunnel.

The tunnels were constructed as a series of arched vaults that document the complex evolution of the tailrace. Rough-hewn shale is the predominant construction material for both tunnels, owing to its abundant occurrence as natural outcrops throughout Harpers Ferry. There are, however, three instances of the use of brick for vaults. One of these brick vaults was used simply to enable the aforementioned curve in the secondary tunnel. The remaining two, on the other hand, correspond to the actual locations of former Armory shops. Specifically, the brick vault in Tunnel A was situated beneath the Polishing Shop, while the straight vault in B ran beneath the Finishing Shop. The former shop was so named because it contained stones for grinding and polishing musket barrels. Workers in the latter shop turned and finished barrels through the use of lathes and other devices.

This image shows how the tailrace appears just inside of the riverside entrance. The disjunction between the various sections of the tunnel is clearly visible here. These changes delineate different construction phases.

The "Y" intersection with Tunnel B on the left and Tunnel A on the right.

The largest chamber of Tunnel A. The vault in the foreground is brick while the rear vault is shale. At the end can be seen the intentional collapse from the B&O Railroad berm construction in 1892 through 1894.

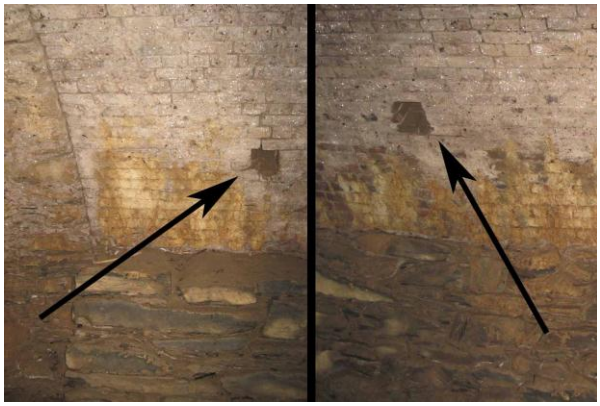


This Geographic Information System overlay shows the position of the tailrace tunnel in relation to the original Smith & Forging Shop (brown outline), the B&O Railroad berm and tracks from 1894, and the modern archeological trenches (Blocks 12 and 13) from the most recent dig. (Image produced by Andrew Lee, NPS).

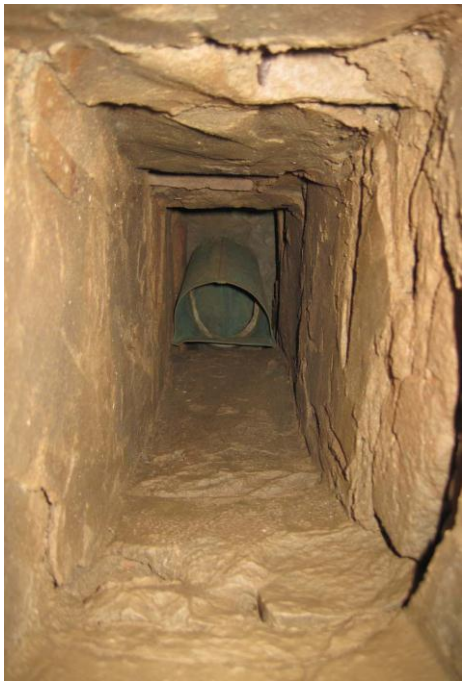
Indirect evidence of that machinery in the form of three drains were discovered in the ceilings of the tunnels. In Tunnel B a 1 ft. square hole capped by a perforated shale block most likely allowed excess water to drain into the raceway. In Tunnel A, two 0.46 ft. square drains on opposite sides of the vault contain copper gutters that directed water away from at least two independent polishing machines.

The arrow points to the location of the drain hole in the last chamber of Tunnel B. In the background can be seen the intentional collapse and backfill from the 1892-1894 B&O Railroad berm construction.

The large drain hole feature in the ceiling of Tunnel B.

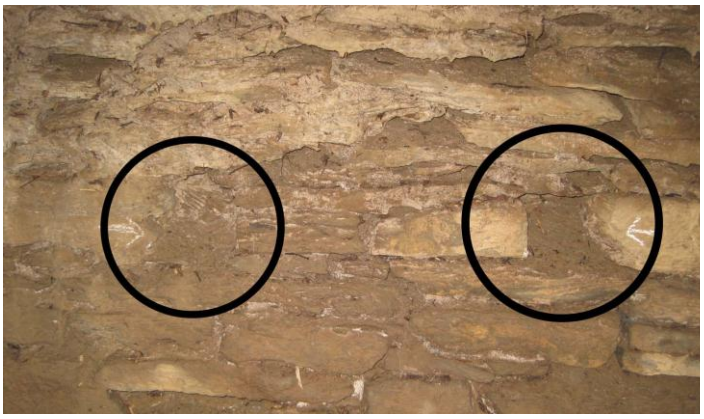


These two photos show the drains in Tunnel A. On the left is the eastern wall while the right side displays the western wall.



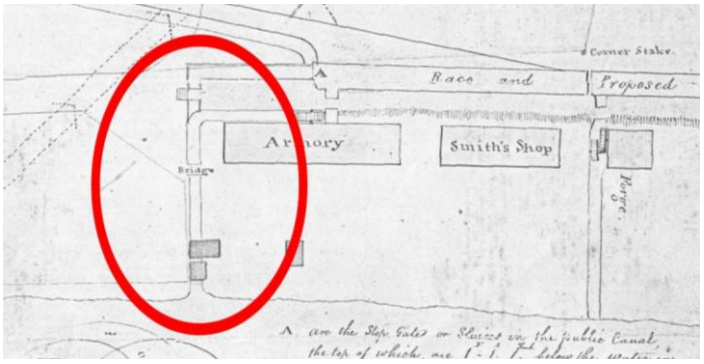
The copper spout as it appears inside of the western drain hole in Tunnel A.

Multiple beam recesses were also noted in the walls of Tunnel A during mapping. Most are situated in the shale walls of the largest chamber two feet above the current floor surface. Forming a series of twelve paired cavities, these suggest that wooden beams 16 ft. in length once spanned this portion of the tunnel for 25 ft. of its length. Plaster remnants in individual recesses clearly show the wood grain of the beams. Their purpose at this location appears directly related to an above ground bridge depicted on a map dated to 1803. Since the original tailraces were not vaulted, a bridge was necessary to connect the shops and allow for armorers to cross the channel.



Two beam voids within the western wall of Tunnel A.

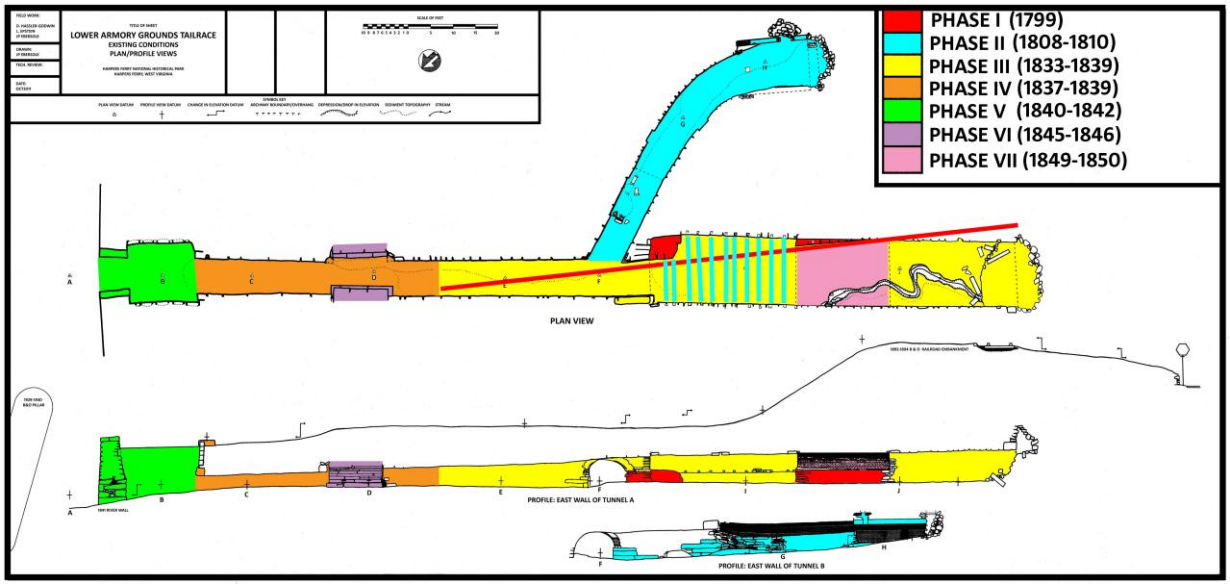
A detail view of one of the beam voids showing plaster that once encased the end of the wooden beam. The impression of the wood grain is still visible today.



The tailrace tunnel, which was the focus of this investigation, is highlighted on this map made by King and Harbaugh, dated 1803, along with the bridge traversing the tailrace channel. (National Archives)

Further down Tunnel A, almost to the area of the intentional tunnel collapse, two more beam recesses were noted. These were nearly 12 inches square, twice the size of the aforementioned beams. Their proximity to the end of the tunnel and to the location of the actual water wheel suggests that they were part of the system, known as a hurst, used to mount the wheel in place.

Many other architectural features were evident as well, giving rise to the conclusion that the tailrace underwent seven main phases of construction and alteration. The first phase, its creation, was determined to date to the original construction of the Armory, 1799-1801. This was a crucial discovery because it meant that this tunnel is one of the two oldest raceways and could reveal critical data about the earliest period of the Armory. Phase II, 1808-1810, was also significant and coincided with an expansion of the



The tailrace plan view with color coding to indicate the phases of construction as currently recognized. (Image by J.P. Ebersole, NPS.)

Armory partially stemming from the increased production of small arms for the eventual War of 1812. During this alteration, Tunnel B was created to furnish water power for the newly built Finishing Shop. Such an addition meant that the original canal had to be extended eastward another 156 ft. and a third, independent tailrace excavated for the excess water.

Little was to happen with regards to the tailrace following that initial expansion until the 1830s. Between 1833 and 1839 the tunnel was realigned by seven degrees, widened, extended 50 ft. further north, and vaulted over. That encompassed Phases III and IV respectively. Next, during Phase V, the B&O Railroad created a new river wall and culvert at the entrance of the tunnel to support a trestle system for two train tracks. This occurred between 1840 and 1842. The last two phases involved changes necessitated by the construction of new workshops at the Armory. During Phase VI, the new Smith & Forging Shop was built. Since the building had a 90 ft. tall smoke stack situated directly over top of the location of the tailrace, engineers had to reinforce the arch in Tunnel A. This occurred around 1845. Finally, the Polishing Shop was built above the back of Tunnel

A between 1849-1850. The new shop necessitated a brick vault spanning 16 ft. With that final alteration, the tailrace continued to function unchanged until the demise of the Armory in 1861.

Perhaps the most important finding of the investigation is that this tailrace is intact and stable. The other tailraces may also be well preserved despite being no longer accessible due to sedimentation. The integrity of this open tunnel is a tribute to the expertise and skill of the engineers and laborers who erected it in the 19th century. Discovering that the tailrace forms a "Y" further tells us that some of the other tunnels may have had similar splits. This, in turn, suggests that the Armory shops may have had supplementary water power potential not directly inferred from the reports by the Superintendents who ran the facility.

Further work, however, remains to be completed in order to understand what the tunnel can tell us about the Armory and its organization. Features such as the tailrace tunnel demonstrate the importance of documenting the cultural resources at Harpers Ferry NHP. The results of the investigation will be incorporated into the interpretation of the park. It will offer visitors a glimpse of America's industrial heritage of the 1800s without risking their safety by venturing into the tunnel or causing harm to the sensitive archeological features and wildlife habitat within. Nevertheless, with only one tunnel open and the others already silted by the river, this is inevitably a race against time to document these tunnels before they are erased, both from the landscape and our shared cultural memory.

By J.P. Ebersole, Archeologist, Harpers Ferry National Historical Park

The tailrace culvert as it appeared just after Hurricane Sandy in 2012. The archway is visible just above the water line in the center of the photograph. Repeated inundations have silted in other tunnel entrances preventing their documentation.